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December 2018

National Aeronautics and Space Administration

COMMERCIAL CREW

Agenda

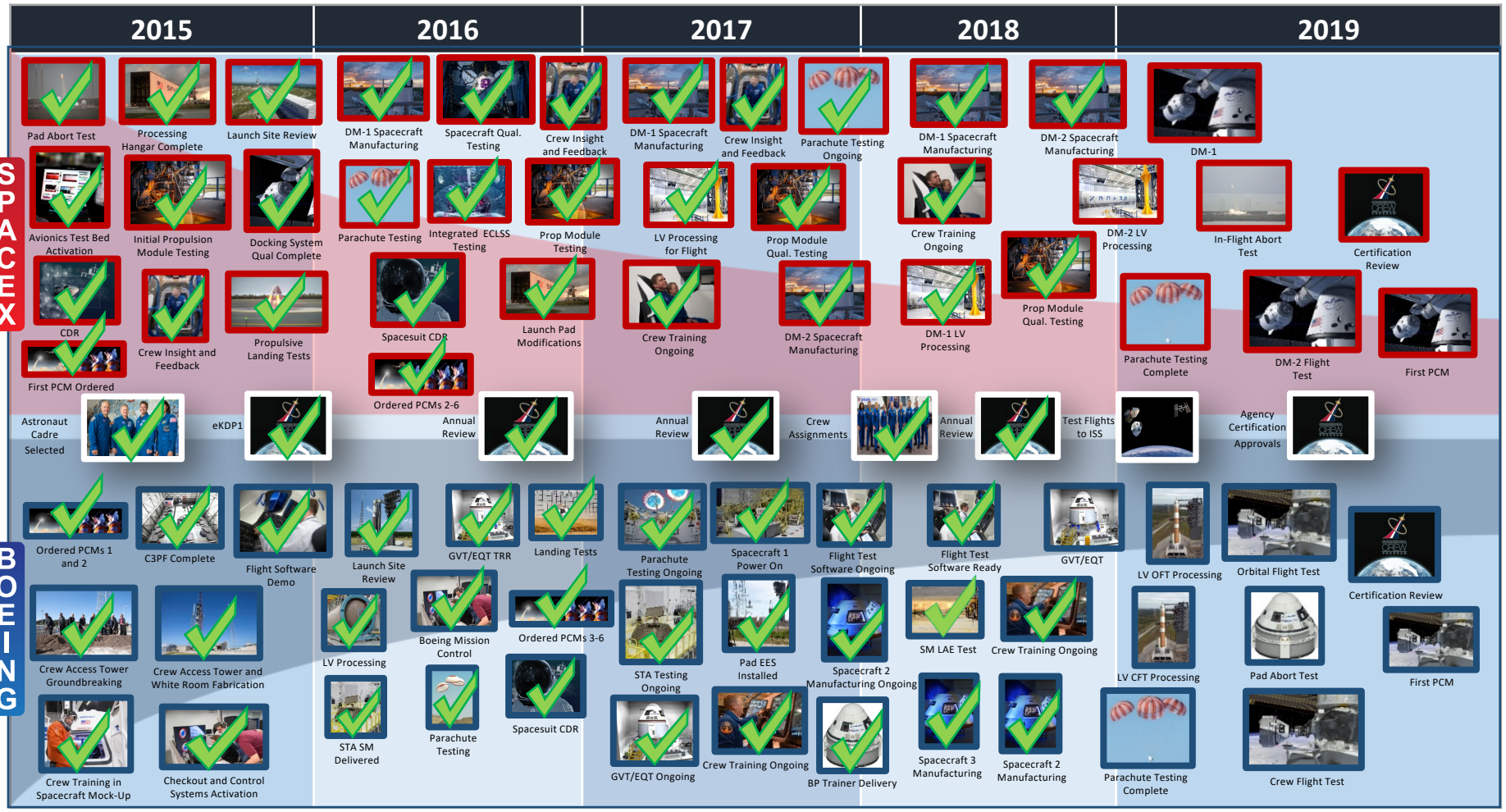
- **Commercial Crew Program (CCP) Status**
  - Program Progress
  - Timeline to the International Space Station
- **Boeing Test Flight Status**
- **SpaceX Test Flight Status**
- **Space Act Agreement Status**
  - Blue Origin
  - Sierra Nevada Corporation
- **Enabling Commercial Space**
- **Summary**

Program Progress

CCP has made significant progress over the last quarter

- **Mission planning and preparations for eight CCP missions are in work**
  - Boeing:
    - March 2019: Orbital Flight Test (uncrewed)
    - August 2019: Crewed Flight Test (with crew)
  - SpaceX:
    - January 7, 2019: Demo Mission 1 (uncrewed)
    - June 2019: Demo Mission 2 (with crew)
- **Space hardware manufacturing, testing and qualification are underway**
- **Continued engagement as the providers perform critical test and verification events**
- **Continue to make progress in the burn down of key certification products with the providers**
  - Progress for each partner is included in provider-specific sections of this briefing

Timeline to the International Space Station

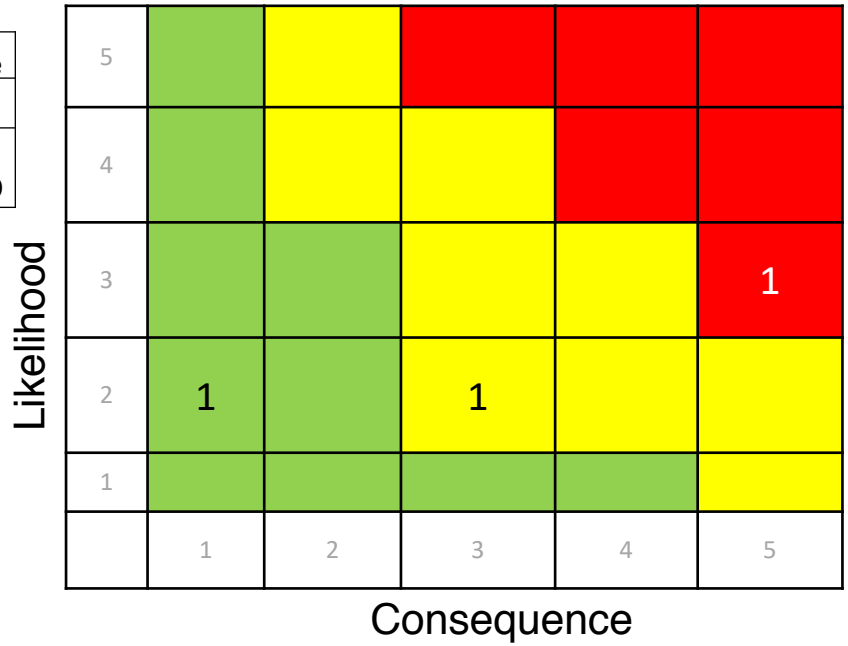


Last Updated
Nov 2018

CCP Top Programmatic Risks

Programmatic Risk = Likelihood x (Highest of Non Safety Consequences (C, S, P))

LxC	Trend	Risk Title	Risk ID Number	Office
3x5	NC	Inability to Meet LOC	CCP-SEI-2015-1	SE&I
2x3	NC	DoD Search and Rescue Training Schedule	CCP-GMO-2015-4	GMO



Trend Key: NC = No Change, I = Increase in Risk, D = Decrease in Risk

As of October 16, 2018

Boeing Test Flight Mission Status

Boeing Accomplishments

Design, Development, Test, and Evaluation

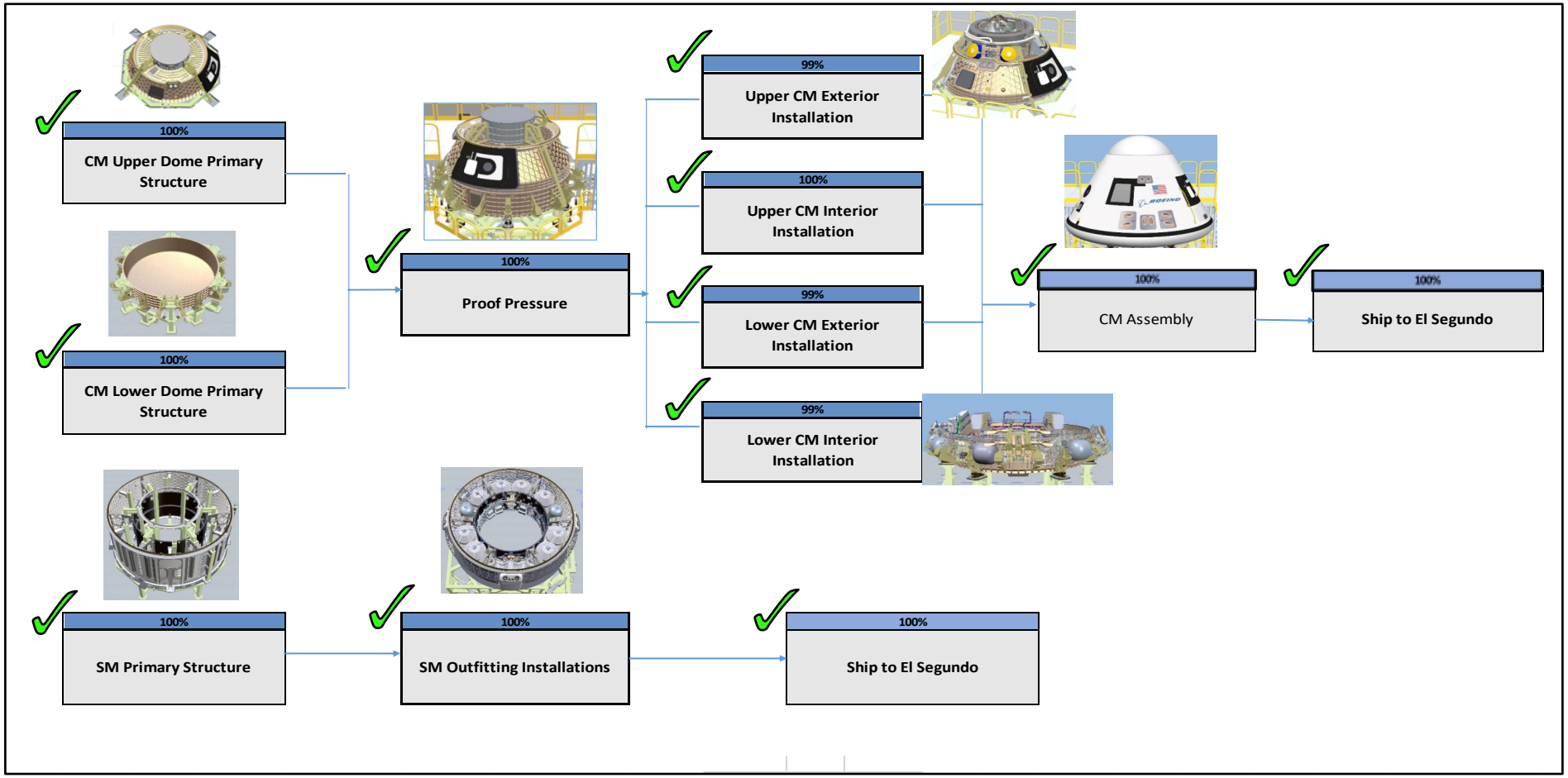
- **System Level**
  - Structural Test Article (STA) campaign testing progressing towards closure at Huntington Beach, 13 of 15 tests completed
    - Shock Development test
    - Launch Vehicle Adapter Integrated Loads
    - On STA Sep-Bolt testing
    - Launch Vehicle Adapter Jettison test
    - Command Module Fixed Base Riser test series
    - Launch Vehicle Adapter Skirt Jettison test
    - Base Heat Shield Separation test
    - Forward Heat Shield/Parachute Impact test
  - Remaining 2 STA test series:
    - Fixed Tunnel test series underway, Unit and Ascent Loads in work
    - Ascent Cover Separation offline test series in work
- **Subsystem Level**
  - Land Landing Qualification Testing completed (all 14 tests)
  - Parachute System Qualification Testing underway (3 of 5 completed)
  - Parachute System Reliability Testing underway (1 of 6 completed)
  - Service Module Hot Fire Low Altitude Abort firing commenced
    - Authority to proceed with valve design corrective action granted
  - NASA Docking System Shock test series, planned to start in early 2019
- **Completed Joint Tests with ISS**
  - Joint testing and analysis required for ISS integration is progressing
  - Completed Joint Tests:
    - Command & Telemetry Routing test
    - CST-100 to C2V2 RF Interface Test
    - Power Quality and Electromagnetic Compatibility
    - CST-100 to NASA Docking System interface test

Fixed Tunnel Test:
Unit & Ascent Loads

Low Altitude Abort Firing

Boeing CFT Spacecraft Production Status

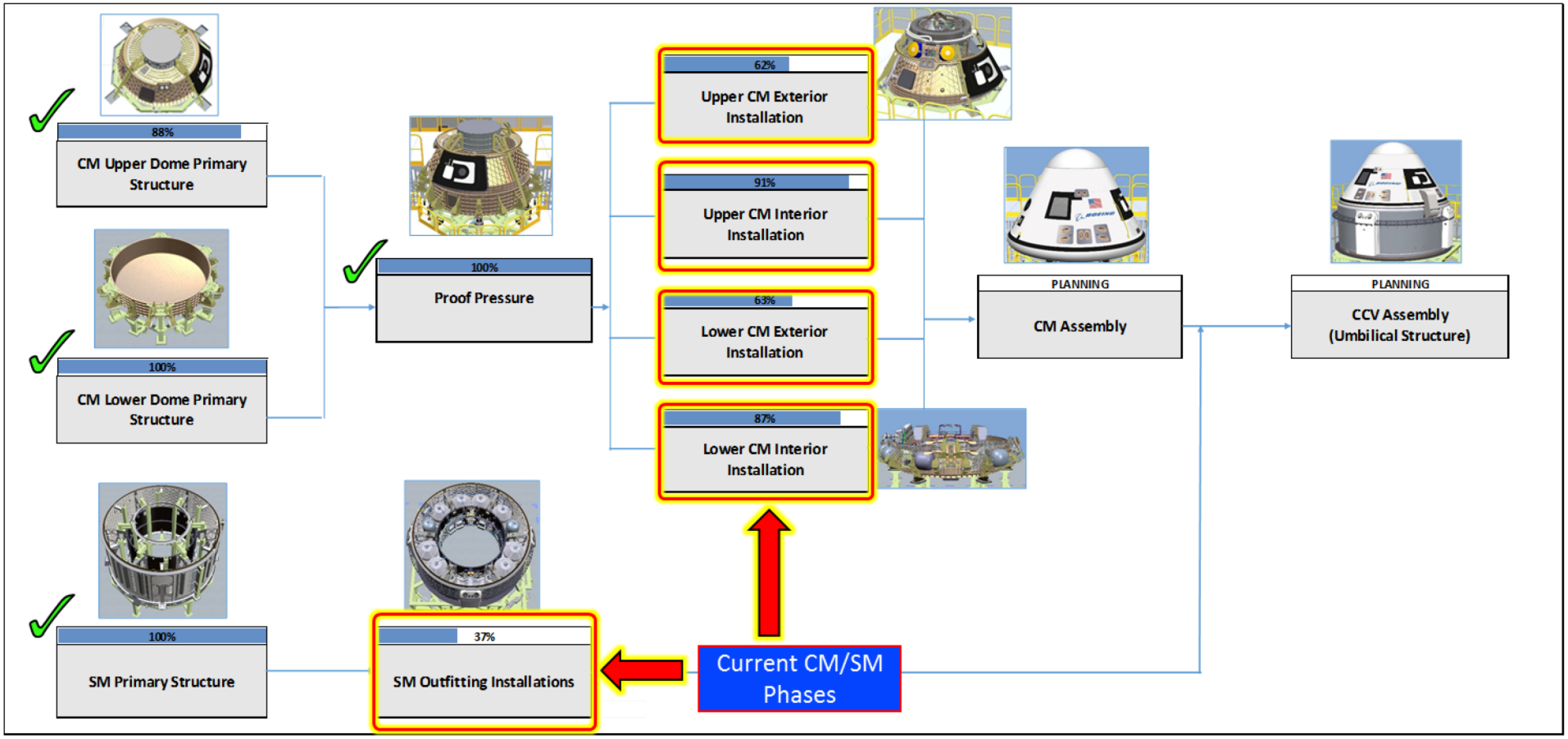
Spacecraft #2 (SC#2): Environmental Qualification Test (EQT) vehicle and Crewed Flight Test (CFT) production build progress



- **SC#2 Status: Currently, in the CM Assembly Phase and the SM Integrated Assembly**
  - EQT Service Module and Crew Module have shipped to El Segundo to support EQT testing

Boeing OFT Spacecraft Production Status

Spacecraft #3 (SC#3): Orbital Flight Test (OFT) production build progress



- **SC#3 Status: Currently, in the Upper Dome Assembly Phase, the Lower Dome Assembly Phase, and the Service Module Integrated Assembly**
  - Continuing with Upper and Lower Dome harness and sensor installations
  - Hatch installation and off-line panel build-up/tube welding in-work
  - Progressing towards Command Module/Service Module mate targeting early 2019

Boeing Launch Vehicle Production Status

- **Atlas V (AV-080) OFT Launch Vehicle**
  - Booster, Centaur, and Launch Vehicle Adapter nearing final build completion
  - Booster
    - RD-180 Engines installed and booster is scheduled to ship to Cape Canaveral Air Force Station in late November
  - Centaur
    - Production complete – Arrived at Cape Canaveral Air Force Station
  - Launch Vehicle Adapter
    - Production complete – Arrived at Cape Canaveral Air Force Station
- **Atlas V (AV-082) CFT Launch Vehicle**
  - Booster
    - Production near completion
    - Engine installation underway
  - Centaur
    - RL-10s and all feedlines are installed
    - Production complete targeted for late December
- **Cape Canaveral Space Launch Complex 41**
  - Crew Access Arm Common White Room Installed onto tower
  - Crew Access Arm functional testing completed

Atlas V Centaur, AV-080 (OFT)

Atlas V Adapter, AV-080 (OFT)

Common White Room

Boeing Operations Status

- **Flight Operations Reviews**
  - **ISSP Joint Flight Operations Review held**
    - Focused on Joint NASA ISS/Boeing Flight products used during rendezvous, departure and docked joint operations
  - **Boeing Mission Operations Flight Operations Review held**
    - Focused on Boeing Flight Operations products during pre-launch, launch, ascent and landing
  - **All Mission Operations products (Joint and Boeing) published**
    - Flight Rules, Launch Commit Criteria, Procedures, Ops Interface Plans, Flight Plans
- **Operations Training and Simulations**
  - **Joint Ascent Simulations with ULA and NASA**
    - OFT Integrated Crew Exercise prelaunch simulation completed
    - On-Pad Crew Emergency Egress testing completed
    - Atlas 5 Launch/Ground Team training completed for NASA CCP personnel
  - **Joint Simulations with ISS Program**
    - Three generic Joint Rendezvous and Docking simulations with ISS Program and Boeing completed
  - **Landing Simulations**
    - Landing and Recovery Team Paper simulations completed
    - Landing Systems Rehearsal completed
- **Crew Operations and SLC-41**
  - **Emergency Egress System validation test completed**
    - Evacuated 12 personnel from Crew Access Tower
    - Exercised Emergency Egress System with Crew
    - Performed crew handover operations at Triage Site 12 post evacuation from base of pad

OFT Simulation

Landing System Rehearsal

Egress System Validation

SpaceX Demo-1/Demo-2/Crew-1 Mission Status

SpaceX Accomplishments

- **Design, Development, Test, and Evaluation**
  - Dragon Development
    - Completed Draco/SuperDraco Validation Prop Module testing at McGregor
    - Completed Structural Qualification
    - Docking system tests complete
  - SpaceX Parachute Testing
    - 5 qualification tests completed in 2018
  - Spacesuit qualification complete

- **Design, Development, Test, and Evaluation (cont.)**
  - Falcon 9
    - Completed Vehicle Integration Review agreement for Block 5 configuration for human rating
  - Merlin 1D and MVAC qualification completed
  - LC-39A Crew Access Arm installed and Ground Operation review completed
  - Flight Software certification for Demo-1 approaching completion
    - Spacecraft Vehicle Hardware in the loop test complete
    - Stage Test with ISS completed
    - Both Dragon propulsion validation module completed
  - Qualification Test Reports of Crew Dragon and Falcon 9 hardware have been delivered for NASA review/approval
  - Completed all Demo 1 Joint SpaceX-NASA tests for software, docking, communications, equipment interface, and capsule environments

Demo 1 Thermal Vacuum Testing

Propulsion Module Hotfire Testing

Demo 2 Crew Training

Demo-1 Vehicle Status

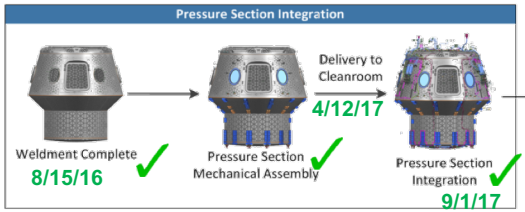

Demo-1 Capsule arrival

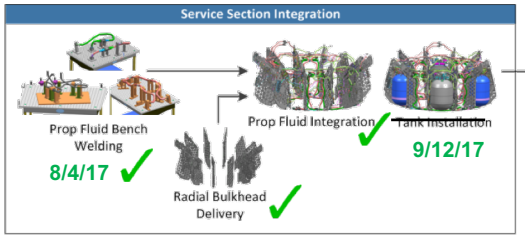

Demo-1 Capsule

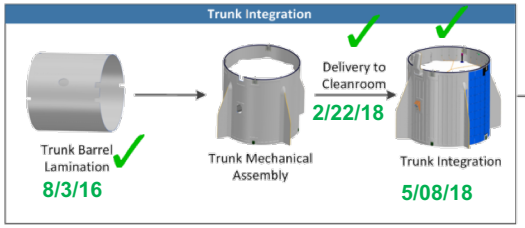

Parachute Testing

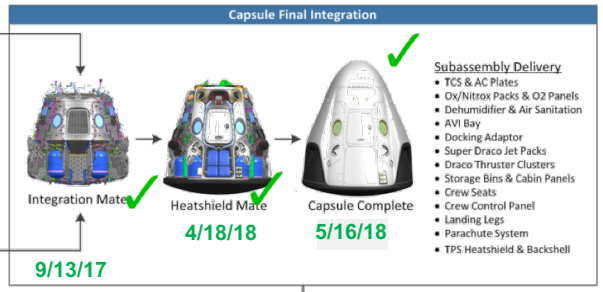
Demo-1 Vehicle

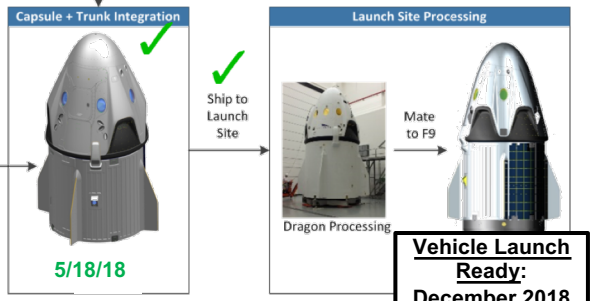
- EMI, Tvac, and Acoustic tests completed successfully
- Capsule delivered to Cape and in final processing
- Heatshield mate complete
- Trunk solar array integration and proof loading complete
- Completed main and drogue parachute installation
- Completed interior closeout inspections
- Nose cone delivered to KSC and installed









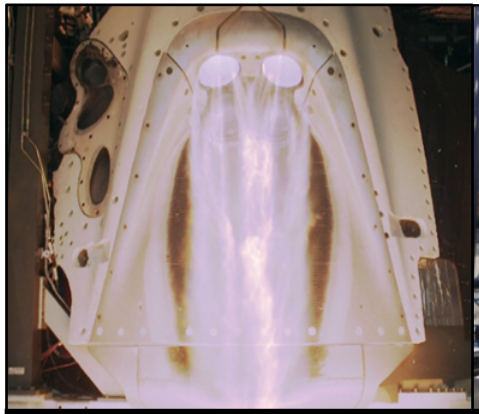


Vehicle Launch Ready:
December 2018

Demo-2 Vehicle Status

Demo-2 Dragon

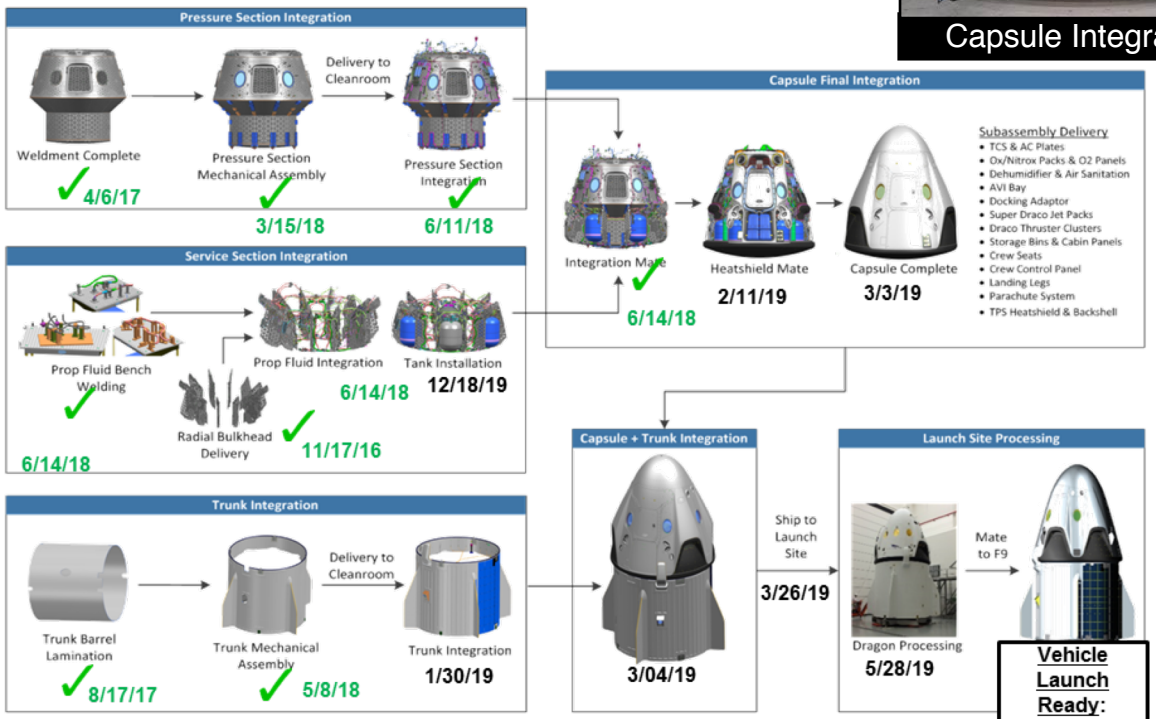
- Started build on the first Demo-2 seats
- Completed all on-vehicle welds
- Pressure Section to the Service Section integration mate complete
- Ongoing vehicle integration in cleanroom
- Trunk primary structure complete
- Avionics Bay, components, and harnesses installed
  - Initial power up and testing complete
- 6 of 8 Super Draco's have been hot-fired at McGregor, Texas



Pad Abort Module Sim

Demo-2 Trunk

Capsule Integration

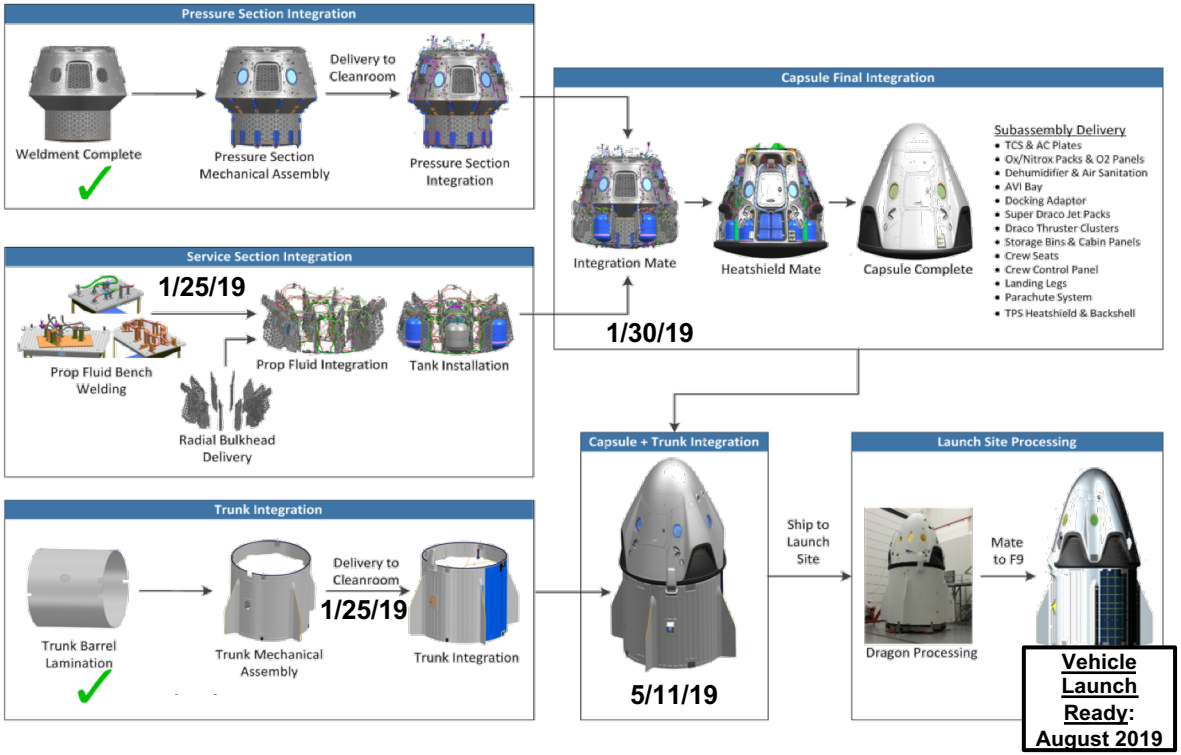


Crew-1 Vehicle Status

SpaceX Meets Crew-1 Team

Crew-1 Dragon

- Capsule through mechanical assembly and structural ATP
  - Crew-1 capsule has completed ATP testing and is undergoing post-test inspections
- Prop Fluid Bench Welding has started and Radial Bulkheads have been delivered to the cleanroom



SpaceX Launch Vehicle & Pad 39A Status

- **Falcon 9**
  - F9 1st Stage
    - Proof test complete
    - ATP stage firing complete
  - F9 2nd Stage
    - Proof test complete
    - ATP Stage firing successfully occurred
  - First F9 Block 5 flew on Bangabandhu mission

- **Pad 39A**
  - Successful Crew Arm Seal testing
  - Crew Access Arm Installation complete
  - Delta Launch Site Operational Readiness Review complete

F9-55 Block 5 Launch F9-60 Launch

LC-39A Crew Access Arm

SpaceX Operations Status

- **Operations**
  - Completed final Flight Operational Reviews
- **Operations Training and Simulations**
  - Finalized CCP Mission Support architecture and console support requirements for the Un-Crewed Flight Tests
  - Developed the CCP Mission Support Team Training Plan
  - Initiated training for Mission Support Team conducting Joint Simulations, Mission Management Team Simulations
    - Mission Management Team Sims and Joint Simulations with SpaceX
    - Conducted Flight Shadowing Training exercises onsite at SpaceX mission operation centers
    - Pre Launch and Post Landing Simulations completed
- **Crew Operations and LC39A**
  - Successful dry-run of Day of Launch Closeout Crew Procedures with representative crew members, spacesuits and transportation vehicles
  - Spacecraft recovery vessel currently in sea trials for Demo-1
    - Capsule recovery
    - Capsule crew egress verification complete

Joint Medical Triage and Medivac Exercise

Demo 2 Crew Training

Water Recovery Training

Space Act Agreements

Blue Origin Status

No Exchange of Funds Space Act Agreement

- **Technical Exchanges**
  - Cryogenics and structures
  - Design Reviews
  - Launch Vehicle Materials
- **Data Exchange**
  - Various software requests and technical documentation exchanges in work
  - Historical Shuttle data and reports
  - Trajectory software
- **Look Ahead**
  - Milestone #6, Development Update of Ground and Mission Operations, late November 2018
  - Continued Technical and Data Exchange
  - Space Station Processing Facility tour

New Shepard

New Glenn

Sierra Nevada Corporation Status

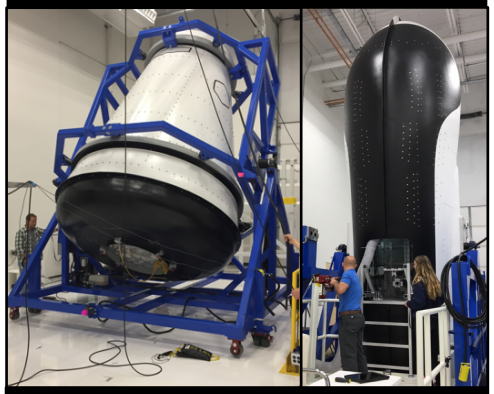
Commercial Crew Integrated Capabilities Space Act Agreement (no exchange of funds)

- **Milestone 4b, Engineering Test Article Flight Testing #2, NASA outbrief - December 2017 (test occurred on 11/11/2017)**
  - Successful uncrewed Dream Chaser engineering test article approach and landing test (ALT-2) at Edwards Air Force Base
    - ALT-2 performance was nominal for orbital vehicle
    - Lessons learned rolled into orbital vehicle design

- **Dream Chaser Orbital Vehicle Design and Development Activities**
  - Dream Chaser Cargo System design at CDR maturity level
    - Conducted systems level Delta CDR review with NASA Oct 29-30, 2018
  - DC-1 (Tail #1) delivery scheduled for March 2019
  - First Cargo Module delivery scheduled for May 2019
  - Dream Chaser Reaction Control System testing continues
  - Dream Chaser Aero Database updates incorporated into CDR design Over 400 Flight Tiles delivered from NASA KSC
  - Multiple successful Cargo Demos performed with NASA
  - First launch late 2020 or early 2021
  - CCICap Milestone 41, summarizing Dream Chaser CDR design and bridge to crewed flight, was presented to NASA November 15, 2018

Dream Chaser ALT-2

DC Tail #1 OV Primary Structure (LM Plant4 – Fort Worth)



Cargo Module and uncrewed Dream Chaser Demonstrations

Enabling Commercial Space

- **CCP helps to facilitate Inter-Agency, Intergovernmental and International partnerships, agreements, and legislation with the strategic goal of enabling the commercial space industry**
  - Inter-Agency Collaboration
    - Department of Commerce (DOC)
    - Department of Defense (DoD)
    - Federal Aviation Administration (FAA)
    - Federal Communications Commission (FCC)
    - National Telecommunications and Information Administration (NTIA)
    - National Transportation and Safety Board (NTSB)
  - Legislation and Regulation
    - "Government Astronaut" classification
    - Mission licensing to include launch, re-entry, launch site and operator
    - Public health and safety protections
    - Jurisdiction and authority during different phases of flight
    - Independent investigation authority
  - Spectrum Usage
    - Ensure secure communication pathway availability
  - Liability and Insurance
    - Cross waivers
    - Financial responsibility
    - Third-party indemnification
    - Government property

ISS Crew EVA

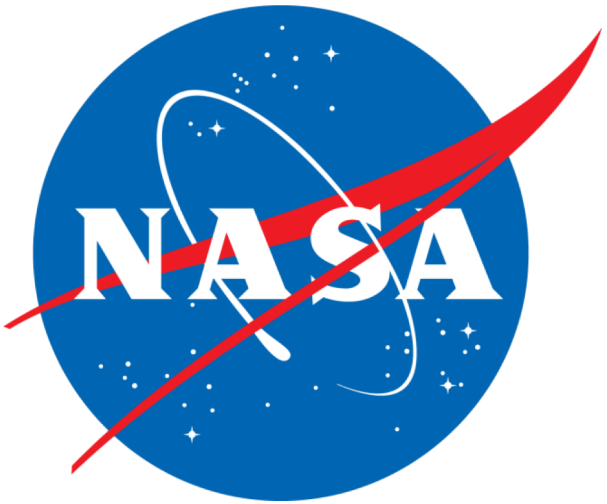
International Space Station

Summary

- **CCP continues to facilitate the development and certification of U.S. industry-based Crew Transportation Systems**
- **Boeing and SpaceX are meeting contractual milestones and maturing their designs**
  - A significant amount of hardware is in development, test, and qualification in preparation for upcoming missions
  - Risks are being identified and important design challenges are being addressed
  - NASA is engaged in meaningful insight
- **Both providers are making tangible progress toward flight tests and crewed missions to the International Space Station**
- **CCP has robust and efficient processes for certification, including addressing waivers and deviations**
  - Progress is being made in the burn down of key certification products with the providers
- **Crew members have been assigned to missions**
- **Inter-agency work continues to enable the commercial spaceflight industry**
- **In preparation for flight, there is significant work ahead**

Boeing CST-100 Starliner

SpaceX Crew Dragon


NASA